A PILOT STUDY ON ACUTE REACTIVE AGILITY TRAINING AND ITS INFLUENCE ON ACL INJURY RISK FACTORS IN COLLEGIATE ATHLETES

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The purpose of this study was to determine if an acute bought of reactive agility training (RAT), exemplified by a Mirror Drill, leads to decreases in biomechanical risk factors typically related to anterior cruciate ligament (ACL) injuries. 3D motion capture data and forces were collected during pre-training and post-training test sessions which involved an unanticipated 45^{o} cuts on both left and right limbs; Participants completed an acute bout of RAT using a Mirror Drill in between testing sessions. Knee and hip kinematics and kinetics were recorded and calculated. Initial findings indicate athletes performed cutting with greater knee and hip flexion following an acute bout of RAT. If biomechanical ACL injury risk factors are reduced following an acute RAT, coaches and athletes could benefit from incorporating such functional drills into warm-up routines and prevent injuries.

KEYWORDS: reactive agility training, ACL injury risk factors, female athletes

INTRODUCTION: One of the most prevalent injuries in sports today is non-contact anterior cruciate ligament (ACL) tears (Boden et al., 2000). Specifically, collegiate athletes have demonstrated increased risk for developing ACL injuries during reactive game play. Current literature supports the idea that a majority of non-contact ACL injuries in soccer occur while defending when the opposing team has possession of the ball (Brophy et al., 2015; Kaneko et al., 2016). This trend suggests that athletes injure their ACLs when they are reacting to offense. With frequent acceleration and deceleration changes, cutting movements and back peddling, there is potential for frequent loss of the ligament's integrity due to high stress it undergoes. Common biomechanical ACL injury risk factors during a cutting maneuvers include peak knee valgus, hip internal rotation and abduction angles. Additionally, presence of high peak knee valgus moments during a cutting maneuver is also a risk factor. Despite the years of research investigating ways to reduce these ACL injury risk factors, they continue to remain prevalent.

Most recent research has started to investigate the association between neurocognitive function and ACL injuries or ACL injury risk factors. Literatures suggests there is a link between neurocognitive performance and lower extremity biomechanics during jumping or cutting tasks (Herman & Barth, 2016; Monfort et al., 2019; Porter et al., 2021; Shibata et al., 2018) which are tasks commonly used to asses ACL injury risk factors. Furthermore, it has been shown that athletes who perform poorly on baseline neurocognitive assessments demonstrate knee kinematics and kinetics during a drop jump that are associated with an ACL injury such as increased knee valgus(Herman & Barth, 2016; Monfort et al., 2019; Porter et al., 2021). It is important to note that most studies to date are investigating neurocognitive function and ACL injury risk factors during anticipated movements rather than unanticipated movements. Less is known about neurocognitive function and knee kinematics and kinetics during unanticipated movements and cutting tasks. One study has demonstrated a decrease in neurocognitive performance is related to ACL injury risk factors during an unanticipated cutting task (Shibata et al., 2018), however more research is needed.

In the pursuit of gaining a competitive edge, athletes and coaches constantly seek innovative drills to enhance performance. Traditional agility drills require athletes to move around a set of pre-planned motions while focusing on rapid and accurate direction changes, primarily emphasizing physical and technical skills. However, more recently there has been as rise in recognizing the importance of incorporating cognitive processes into agility drills (Inglis & Bird, 2016). These cognitive agility drills may better prepare the athletes for competition and reduce injuries. Reactive Agility Training (RAT) has emerged as a method assess and train an athlete's physical, technical, and cognitive qualities. During RAT drills athletes react and change direction in response to human stimuli which is game like than traditional agility drills in which athletes complete a set of pre-planned movements. Studies support the validity and reliability of RAT and moreover, the literature highlights that RAT drills not only improve neurocognitive abilities and enhance reactive responses but also serve as an indicator of injury risk, specifically related to ACL injuries (Inglis & Bird, 2016; Porter et al., 2021; Porter et al., 2022). Reactive agility training has been shown to improve reaction time and change of direction time, decrease injury prevalence and be reliable in differentiating between high and low-performing athletes (Adıgüzel et al., 2018; Gabbett et al., 2008; Inglis & Bird, 2016; Mijatovic et al., 2022; Sheppard & Young, 2006). As stated above while most non-contact ACL injuries happen during a reacting scenario perhaps training in this type of scenario may reduce injuries from occurring. To our knowledge, there is no literature that investigates the acute effects of reactive agility training and knee kinematics when responding to unexpected stimuli. This is a clinically important topic because athletes, coaches, and trainers are constantly seeking ways to keep themselves or athletes healthy. If reactive agility drills are shown to decrease the ACL injury risk factors and subsequently ACL injuries, then these findings could potentially lead to the development of a training and pregame warm-up routine that is more effective than current widely used agility drills.

Therefore, the purpose of this study was to determine if an acute bought of reactive agility training led to decreases in biomechanical risk factors related to ACL injuries. It was hypothesized that an acute bout of RAT would lead to decreases in knee valgus, hip internal rotation and hip adduction angles during an unanticipated cutting manuever.

METHODS: Participants were recruited through the University of Hartford collegiate athletic teams. Following signed informal consents, a Medical Questionnaire was completed prior to the start of testing. Retroreflective markers were attached to the skin bilaterally using double-sided tape. The markers were placed on the first and fifth metatarsal, second toe, medial/lateral malleoli of the lower shank, medial/lateral epicondyles of femur, greater trochanter of the femur, jugular notch, cervical spine 7, sacrum L5/S1, iliac crest, PSIS, ASIS, clavicle bilaterally. Cluster plates of markers were fastened bilaterally on the thigh, shanks, and heels using fabrifoam wraps and duct tape to secure placement and limit motion artefact. Following marker placement, the warmup was administered. The warmup consisted of a modification of a standardized and validated dynamic warm-up known as the FIFA 11+ and included running straight ahead, hip out/hip in, quick forwards/quick backward, walking lunges, and lateral jumps.

Following the dynamic warm-up participants completed pre-training tests. During pre-training, participants were asked to run and complete an unanticipated 45 degree cut to the left, right or backwards. Cutting direction was randomized and athletes were notified of the direction immediately after the start of their run by visual cues. Twelve successful trials were collected (4 in each direction). A successful trial was defined as the cutting foot was on the centre of force platform and did not slow down throughout the change of direction movement. Average velocity of the sacrum L5/S1 marker was calculated and recorded to confirm.

After pre-training testing was complete participants the completed the intervention which consisted of performing a “Mirror Drill” that simulates matching an opponent’s actions during a game situation. Three cones were be set up in line approximately 2m apart. One of the participants identified as the “Offense/Leader” and one of the participants identified as the “Defense/Follower.” Both players lined up approximately 2m back from the cones on opposite sides facing each other. During the drill the offense leader was instructed to run forward and randomly move between cones by side shuffling and back pedalling to starting spot. The defensive follower’s goal was to follow and keep up with the leader by mirroring their moves. A trial lasted for 30 seconds. After each trial of the Mirror Drill, the participants were given a 1-minute break and a printed Borg’s Perceived Exertion Scale to determine their level of exertion. The submaximal range was defined as no higher than “70% of exertion during a game,” which

correlated to a 7 on the Borg's scale. If the participant reported being above 7, they rested prior to continuing. Six training trials of the mirror drill were performed as the intervention.
Immediately following completion of the training, the defensive player completed post-training tests. Similar to pre-training participants were asked to run and complete an unanticipated 45 degree cut to the left, right or backwards. Twelve successful trials were collected (4 per route).
Kinematic and kinetic data were collected during the pre-training and post-training testing using 12 motion analysis camera system (Motion Analysis Corp Rohnert Park, CA USA) and four force platforms (AMTI Inc Watertown MA USA). Inverse dynamic principles were used to calculate joint kinetics at the ankle, knee and hip using Visual 3D (C-Motion Inc Gaithersburg, MD USA). Primary kinematic variables of interest were biomechanical variables related to ACL injury risk during cutting: peak knee valgus, hip adduction, hip internal rotation angles during the deceleration phase of the cut. The deceleration phase of the cut was identified from initial contact to maximum knee flexion.
Given this is a pilot study and a very small sample size at time of submission statistical analysis was not performed. However, with a larger sample size and assuming normal distribution to determine differences between pre-training tests and post-training tests a multivariate ANOVA would be performed. If statistical significance was found then post hoc repeated measure ANOVAs and paired t-tests would be performed. Significance level set at alpha ≤ 0.05.

RESULTS/DISCUSSION: During preliminary pilot testing, four female collegiate lacrosse athletes (avg: 18.5 years) participated in the pre-training tests, Mirror Drill and post-training tests. Peak knee and hip flexion angles as well as peak knee valgus, hip adduction, hip internal rotation angles were identified during the deceleration portion of stance phase of pre and post testing cuttings 45 degree cuts (Figure 1).

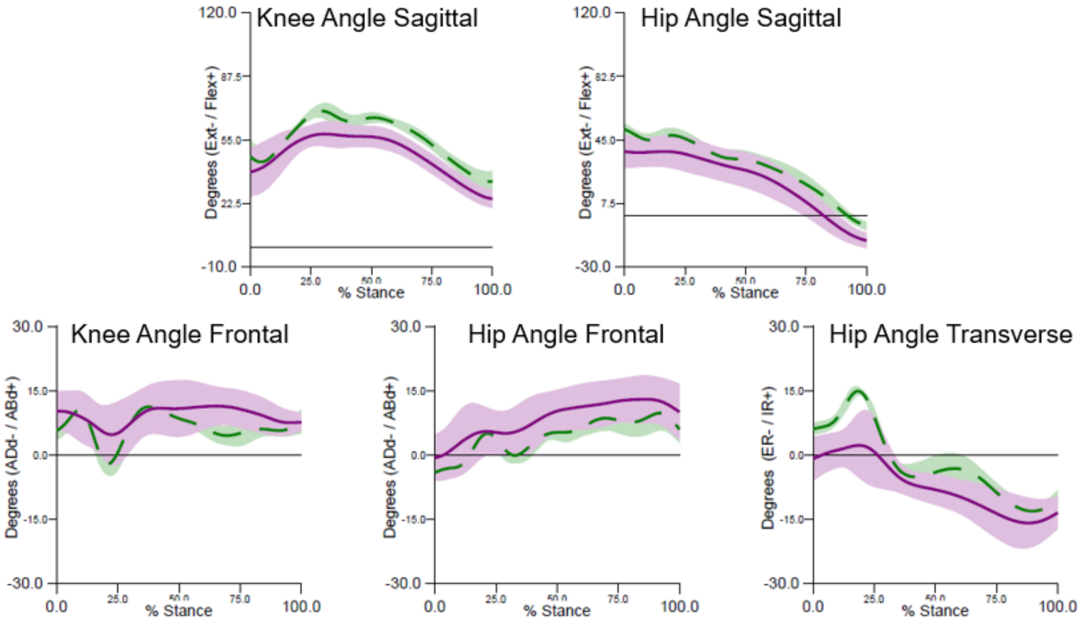

Figure 1: Average (thick line) knee and hip angles and standard deviations (shaded) of 4 athletes during an unanticipated cut to the right during the Pre-training test (green-dashed) and Post-training test (purple-solid) during stance phase. Flexion (Flex), Extension (Ext), Adduction (ADd), Abduction (ABd), External Rotation (ER) and Internal Rotation (IR) Angles are graphed.

In this preliminary pilot study, we aimed to investigate the acute effects of Reactive Agility Training (RAT) on biomechanical risk factors related to anterior cruciate ligament (ACL) injuries. While only four female collegiate lacrosse athletes participated in the study thus far part of this pilot study was to confirm completion of intervention and testing. All four athletes successfully completed the sessions.
Initial findings from four athletes indicate the athletes complete the unanticipated cutting tasks with more knee and hip flexion and a variation between biomechanical ACL Injury risk factors (knee valgus, hip abduction and internal rotation) was observed pre and post training test

sessions (Figure 1), however with such a small sample size no conclusions can be made at this time. A larger sample of 20 is aimed for completion of this project. The goal is that at the time of the conference a larger sample will be presented with more conclusive results. This project is actively recruiting and testing collegiate athletes to expand the sample size to enhance the study's statistical power.
In conclusion, this pilot study serves as a preliminary exploration and a solid foundation of a research project investigating the acute effects of Reactive Agility Training on biomechanical risk factors related to ACL injuries.

CONCLUSION: Understanding acute effects of Reactive Agility Training, exemplified by the Mirror Drill, may reduce ACL injury risk factors. Coaches, physical therapists, and athletic trainers could benefit from incorporating such functional drills into warm-up routines pre-game or pre-practice, potentially offering a more effective approach than traditional agility drills. Although further research is warranted to validate these findings, the study sets the stage for a potential breakthrough in ACL injury prevention strategies for athletes.

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